**SPECTRAL OPACITIES AND EQUATIONS OF STATE OF COSMIC BODY MATERIAL VAPORS.**
I.Kosarev, Institute for Dynamics of Geospheres RAS, Leninsky pr. 38-1, 119334 Moscow, Russia, kosarev@idg.chph.ras.ru

Estimates of atmospheric protective properties determining penetration of cosmic objects into the Earth atmosphere are an important problem in connection with a problem of asteroid danger which is being widely discussed now. These properties play significant role for two processes ablation (for large bodies mainly due to thermal radiation) and mechanical destruction under aerodynamic strength action. Optical and thermodynamic properties of vapors are important characteristics dominating distribution and entrainment of radiating vapor mass arising around a cosmic body during its motion in the atmosphere. These material characteristics dominate origin and development of heated surface shielding process.

Optical and thermodynamic property calculations were carried out for various types of bodies with appreciable differences in chemical composition: H-, C-chondrites, ice and cometary material. Calculations were carried out on the base of 16 elements: Fe-O-Mg-Si-C-H-N-S-Al-Ca-Na-K-Cr-Mn-Ti-Ni. The average percentage for H-chondrites was taken from [1]. Data of [2] were used for carbonaceous chondrite. The probable composition of Comet Halley (one a half of it is water and the other half is a chondritic dust) was adopted as a composition of cometary matter.

Chemical composition for every pair values of the temperature and density was determined in the thermodynamic equilibrium approximation from the solution of chemical and ionization equilibrium with conservation of nucleus number and electroneutrality. The algorithm of the phase and chemical equilibrium thermodynamic analysis for complex systems based on extremal principles was used [3].

Spectral opacities were calculated similarly to [4,5]. All the main radiative processes were taken into account. Modern published spectroscopic data are used in calculations along with the update version of the atomic physics program. The last one uses configuration interaction (CI) methods [6] and random phase approximation with exchange (RPAE) [7] to take into account correlations in many electron atomic shells. For heavy elements relativistic variant of self-consistent field Dirac-Fock approximation was also used. Absorption in molecular bands was calculated in the just overlapping line approximation.

Influence of plasma non-ideality on optical properties in the case of high densities was determined by using the microfield model.

Tables of optical and thermodynamic properties of cosmic body material vapors in the ranges $T = 2$-$40$ kK and relative density $\delta = 10^{-5}$-$10$ ($\delta = N/N_L$, where $N$ is the total number of nuclei in the mixture, $N_L$ is the Loschmidt number) were calculated.

Values of vapor mass densities $\rho_L$ corresponding to $N_L$ are equal to $1.08 \cdot 10^{-3}$ g/cm$^3$, $6.688 \cdot 10^{-4}$ g/cm$^3$ and $3.72 \cdot 10^{-4}$ g/cm$^3$ for H-chondrite, C-chondrite and cometary matter respectively.

Some examples of obtained results are presented in Fig. 1-3.

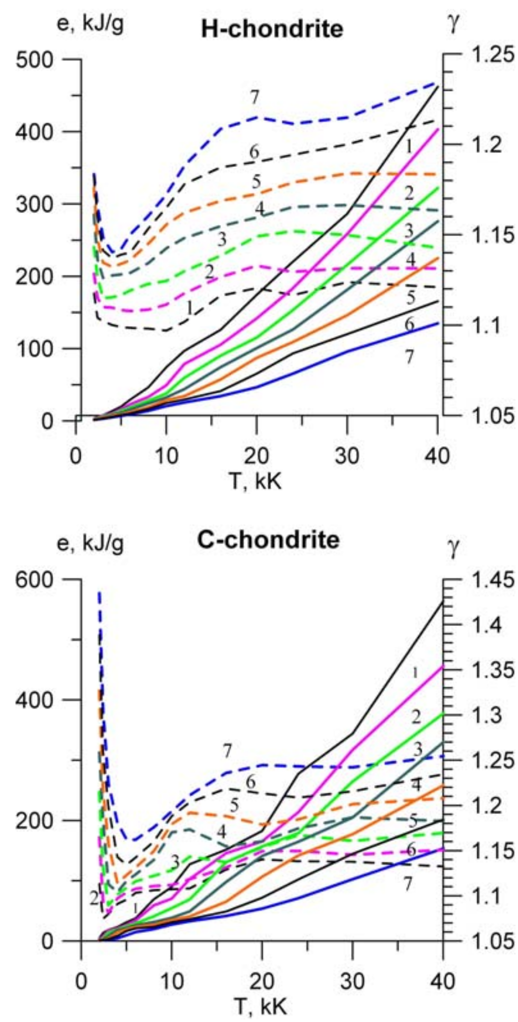


*Figure 1.* Dependencies of the specific internal energy $e$ and adiabatic index $\gamma$ on the temperature $T$ for various densities chondrite vapor.

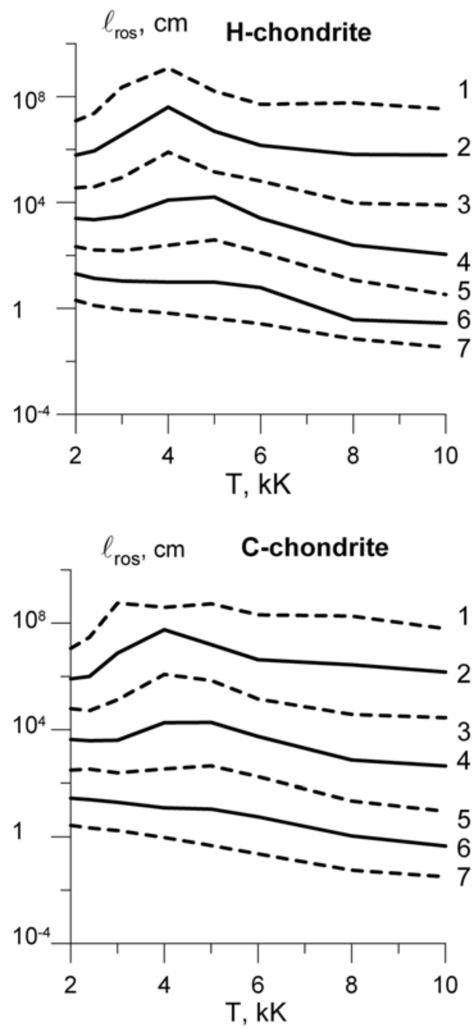


*Figure 2.* Dependencies of Rosseland paths on the temperature T for various densities chondrite vapor.

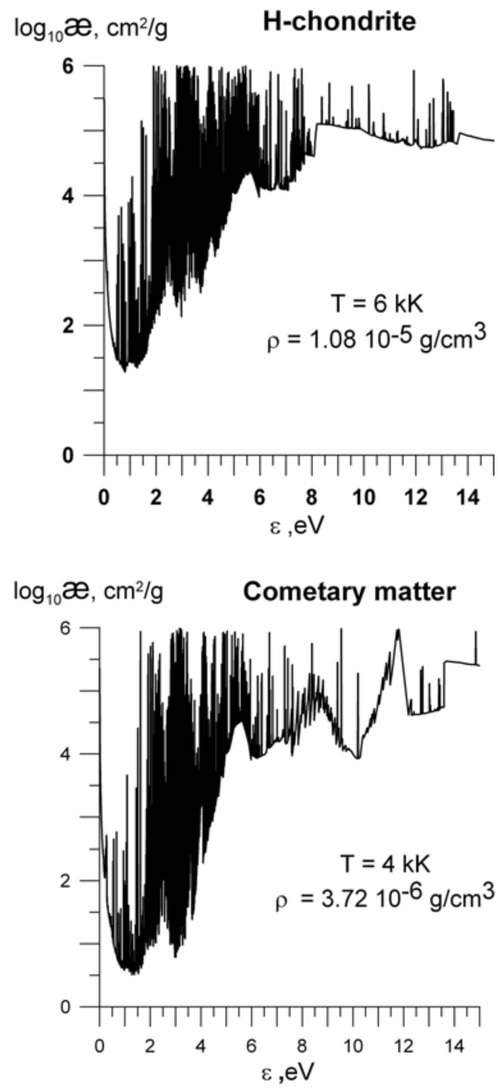


*Figure 3.* Decimal logarithms of mass absorption coefficients.

The numbers near each curve in Fig. 1 and 2 correspond to values of the relative density $\delta$ as 1 - $\delta = 10^{-5}$, 2 - $\delta = 10^{-4}$, 3 - $\delta = 10^{-3}$, 4 - $\delta = 10^{-2}$, 5 - $\delta = 10^{-1}$, 6 - $\delta = 1$, 7 - $\delta = 10$.

Obtained values of Rosseland paths and spectral absorption coefficients (even without carrying out gasdynamic calculations) show that the strong shielding surface regime occurs for all types bodies with a size more 10 m at pressures in a vapor layer near 10 MPa and more.

The effect of shielding for considered bodies is essential at their motion in the atmosphere up to 30 km and lower. It decreases the ablation rate by thermal radiation and may lead to deeper penetration of cosmic bodies in the atmosphere in comparison with estimates not taking into account this effect [8].

**Acknowledgement.** This publication is based on the work supported by RFBR (project no. 07-05-00026).

**References:** [1] Jarosewich E. (1990) *Meteoritics*, **25** (4), 323-337. [2] Anders E. and Grevesse N. (1989) *Geochim. Cosmochim. Acta,* **53**, 197. [3] Vatolin N.A., Moiseev B.G., Trusov B.G. (1994) *Thermodynamic modeling in high temperature nonorganic systems* (in Russian). [4] Borovička J., Popova O.P., Golub' A.P., Kosarev I.B., and Nemtchinov I.V. (1998) *Astronomy and Astrophysics,* **337**, 591-602. [5] Kosarev I.B. (1999) *J. Eng. Phys. and Thermophys.,* **72** (6), 1030-1038. [6] Nikitin A.A. and Rudzikas Z.B. (1983) *Grounds of the Theory of Atom and Ion Spectra* (in Russian). [7] Amusia M.Ja. (1987) *Atomic photoeffect* (in Russian). [8] Kosarev I.B., Loseva T.V., Nemtchinov I.V. (1996) *Solar System Res.*, **30** (4), 265-278